Status and further development of the Trigger Time Event system for fusion experiment Wendelstein 7-X

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ABSTRACT

The Trigger Time Event System is used by the control and data acquisition systems of the central control systems, the technical components and the diagnostics of W7-X for their time synchronization, for processing events and for generating and receiving trigger signals. This use cases makes it necessary to adapt the TTE system to the changing requirements of users.

After an introduction to the functions and structure of the TTE system, this contribution describes the current expansion status of the TTE system and the planned modifications and expansion of the hardware and software of the TTE system. Finally, the current status of the planned work on the TTE system for the upcoming W7-X operational phase Op2.2 is presented. The contribution ends with a summary.

FUSION EXPERIMENT W7-X

I. **The superconducting stellarator W7-X is equipped with 50 nonplanar and 20 planar coils.**
II. **For plasma heating can be used: ECRH heating, Neutral Beam Injection (NBI), and Ion Cyclotron Resonance Heating (ICRH).**
III. **W7-X is equipped with a large range of plasma diagnostic systems (56 diagnostics in OP2.2).**
IV. **First plasma operation took place in December 2015.**
V. **4 operational phases have been successfully completed, in which a total of 6,559 plasma discharges with a total plasma time of 473 min have been generated.**
VI. **The next operational phase OP2.2 will start the scientific plasma operation in September 2024.**

FUNCTIONS OF THE TTE SYSTEM

I. **Generation of a global time for all CoDa components of W7-X,**
II. **Synchronization of all local time counters of the lTTE systems of the technical components and diagnostics,**
III. **Providing event messages processing and standard trigger signals,**
IV. **Providing time and trigger related functions like:**
   1. Time capturing,
   2. Pulse sequence generation,
   3. Time delays,
   4. Impulse counter,
   5. Event trigger processing.

W7-X CONTROL SYSTEM

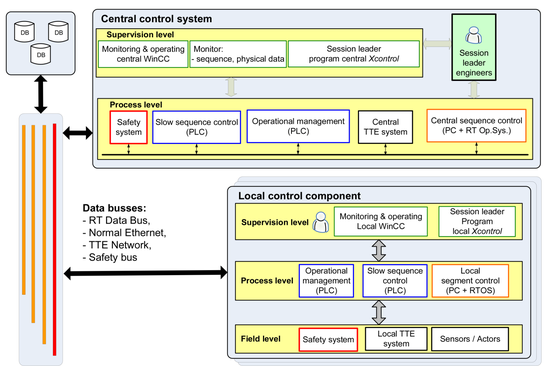


Fig. 1. W7-X control system structure

TTE SYSTEM ARCHITECTURE

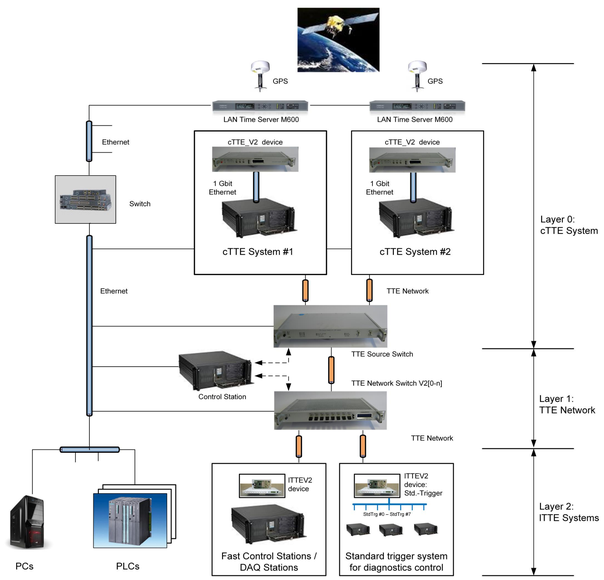


Fig. 6. Overview of TTE system architecture

OPERATION OF W7-X

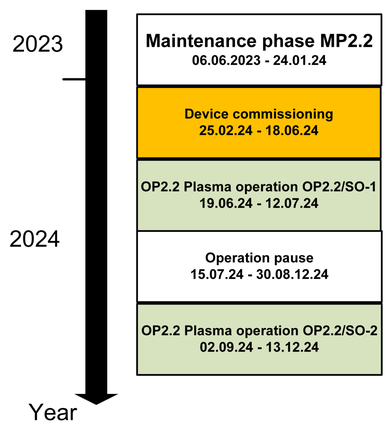


Fig. 2. Operational phases of W7-X

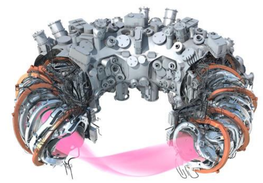


Fig. 3. CAD model of W7-X

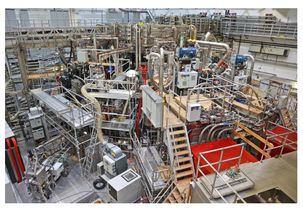


Fig.4. View on W7-X in the torus hall

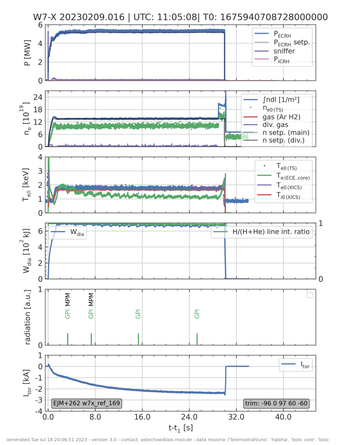
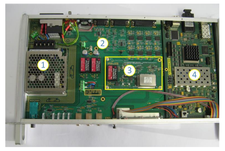


Fig. 5. High power plasma discharge in OP2.1: (high power 5 MW / 30 s / 170 MJ)

NEW DEVELOPMENTS FOR THE TTE SYSTEM



cTTE_V2 device:
- 19” housing,
- Oven stabilized controllable oscillator,
- Virtex 6-130T FPGA card,
- Transmission delay measurement mode.

IRIG B converter:
- Converts the TTE timing messages into a IRIG-B timing signal,

TTE signal switch:
- Switching the cTTE transmission signal between cTTE_#0 / cTTE_#1,

TTE network switch:
- 8 downlink ports,
- Bidirectional data transmission,
- Round Robin mode or priority mode for read out message FIFOs

ITTE_V2 device:
- Redesign of Pulse Sequence Generator module,
- Message sending also in direction of cTTE system,

TTE PROJECT STATUS

Due to the effects of the coronavirus pandemic, the original schedule for the TTE project had to be adjusted.

The lTTE_V2 devices with modified FPGA program will be used in the upcoming OP2.2 operating phase.

The new cTTE_V2 devices and TTE network switching devices will first be extensively tested in an test setup.

The central TTE system will then be converted in the next maintenance phase MP2.3.

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